BSC 2011

MENDELIAN GENETICS PROBLEMS

The following problems are provided to develop your skill and test your understanding of solving problems in the patterns of inheritance. They will be most helpful if you solve them on your own. However, you should seek help if you find you cannot answer a problem. Most of these problems are fairly simple, yet mastering their solutions will provide the background to solve many genetic puzzles and will strengthen your understanding fundamental principles of genetics.

A. PROBABILITY

1. You and your spouse have no children. You stand to inherit a sizeable fortune from your crazy Uncle Irving if you can produce three daughters in your family of three children. What is the probability of doing just that?

2. If you could convince Uncle Irving that simply having three children all of the same sex would do, then what would be the probability of your receiving the inheritance?

3. In quest of the family stipulated in #2 above, you produce a boy as your first child. Now what is the probability of inheriting the fortune?

4. Why are the answers to #2 and #3 the same?

B. MONO-, DI-, AND POLYHYBRID CROSSES; DOMINANCE AND RECESSIVENESS

In all of the following problems, capital letters will be used to denote a dominant trait, and lower-case letters will be used for the recessive trait.

5. In peas, seeds may be round (R) or wrinkled (r). What proportion of the offspring in the following crosses would be expected to be wrinkled?

   a. RR x rr b. Rr x Rr c. Rr x rr

6. In peas, seeds can be round (R) or wrinkled (r) and either yellow (Y) or green (y). Stem length may result in a tall (T) or dwarf (t) plant.

   a. In the cross (parent A) TTYyRr x TtYyRr (Parent B), how many different types of gametes can be produced by each parent and how many different phenotypes are possible from the cross?

   a. What proportion of the offspring from the cross in part a would be tall with yellow, wrinkled seeds?

   c. In the cross TtYYRr x ttYYrr what proportion of the offspring would be expected to be tall plants with round, yellow seeds?

7. For the purpose of this problem assume that in humans the gene for brown eyes is dominant to that for blue eyes.

   a. A brown-eyed man marries a blue-eyed woman, and they have eight brown-eyed children. What are the genotypes of all the individuals in the family?
   b. What is the probability that the first child produced in parents who are both heterozygous for brown eyes will be blue-eyed?
   c. If the first child is a brown-eyed girl (same parents as in b), what is the probability that the second child will be a blue-eyed boy?

8. Assume that D, E, F, G, H, and I are autosomal genes on different chromosomes. From the mating (parent A) DdeeFfGGHhIi x (parent B) DdEEFFGgHhii:

   a. What is the probability that one of the offspring will have the genotype DdEeFFGghhIi?
   b. What is the probability that one of the offspring will be heterozygous for each allele?
   c. How many different kinds of gametes can be produced by each parent?

C. INCOMPLETE DOMINANCE

9. In cattle, RR = red, Rr = roan, and rr = white. What are the predicted **color** phenotypes and their frequencies for the offspring from crosses between:

   a. a red bull and a white cow
   b. a red bull and a roan cow
   c. a roan bull and a roan cow

10. Given the following information about the inheritance of characteristics in pea plants, answer the questions below:

Y (yellow) is dominant to y (green)
R (round) is dominant to r (wrinkled)
B (bitter) is dominant to b (sweet)
S (smooth) is dominant to s (hairy)
L (long pod) shows incomplete dominance to l (short pod) (Ll is medium in length)

Given this cross: (P_1) Yy Rr Bb SS Ll (male) x yy RR Bb Ss Ll (female)

a. How many different gametes can be formed by the female plant?
b. How many different genotypes are possible in the F_1 offspring?
c. How many different phenotypes are possible in the F_1 offspring?
d. What percent of the F_1 individuals will be
   green, bitter, and smooth _______________
   hairy, medium, and sweet ______________
   round, bitter, and long _________________

D. MULTIPLE ALLELES

11. In humans, the ABO blood groups are controlled by three alleles (only two of which occur in any one individual): the alleles for A and B type blood are co-dominant toward each other, and both are dominant to the allele for O type blood.

a. If a person with type AB blood marries someone with type O blood, what are the possible phenotypes of their offspring?

In the following, determine the genotypes of the parents:

b. One parent has type A and the other has type B, but all four blood groups are represented in the children.
c. One parent has type AB and the other has type B, but of the children 1/4 have type A, 1/4 have type AB, and 1/2 have type B.

12. In the following cases of disputed paternity, determine the probable parent.

a. Mother is type B, child is type O. Father #1 is A; father #2 is AB.
b. Mother is type B, child is type AB. Father #1 is A; father #2 is B.

13. A woman with type A blood has parents who are both type AB and a husband who is a type B. What is the probability that their first child will be a son with type O blood?

E. MULTIPLE GENES

14. In cocker spaniels, the following genotypes and phenotypes are found:

AABB = white A-bb = red aabb = lemon AaB- = black aaB- = liver AABb = grey

a. A red female is mated with a liver-colored male, and one of the pups produced is lemon-colored. What are the genotypes of the parents?
b. What proportion of these offspring would be expected to be black?
a. A black male is mated with a liver-colored female, and they produce the following pups:
a.

3/8 black	1/8 red
3/8 liver-colored	1/8 lemon-colored

What are the genotypes of the two parents?

d. If two cocker spaniels of the genotypes below are mated, and eight pups are born, what is the most likely distribution of coat colors in that litter?

P_1 AaBb x AABb

______white ______red ______lemon ______black ______liver ______ grey

15. A dominant gene, A, causes yellow color in rats. The dominant allele of another independent gene, R, produces black coat color. When the two dominant genes occur together (A-R-), they interact to produce grey coat color. Rats of the double recessive genotype are cream-colored. If a grey male and a yellow female are mated and produce approximately 3/8 yellow, 3/8 grey, 1/8 cream, and 1/8 black, what were the genotypes of the parents?

F. SEX LINKAGE

16. The inheritance of color blindness in humans is due to a recessive gene located on the X chromosome (X linked).

X^{+} (normal) > X^{c} (color blind)

a. If a color-blind boy is born to parents both of whom have normal vision, what are the genotypes of the three individuals?

b. What is the probability that the second child born to that couple will be a color-blind daughter?

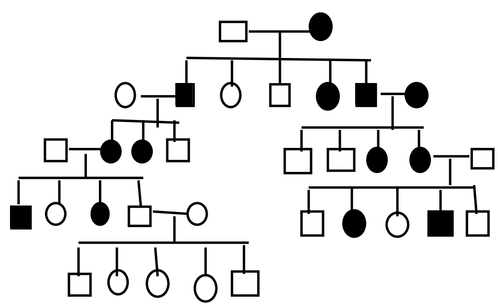
17. In humans, dark hair (B) is dominant over blondness (b), and color blindness (c) is a sex-linked recessive trait. A women has a blond brother, a blond mother, and a dark-haired father. Her brother and her parents have normal vision. She bears the following three children by her blond, normal-visioned husband:

a dark-haired son with normal vision
a dark-haired daughter with normal vision, and
a dark-haired color-blind son

a. Make a pedigree of the entire family showing the probable genotypes of all individuals.
b. What is the probability that her next (fourth) child will be a color-blind boy?
c. If her fourth child is a boy, what is the probability that he will have dark hair?
d. What is the chance that her next four children will all be girls?

G. HUMAN GENETICS

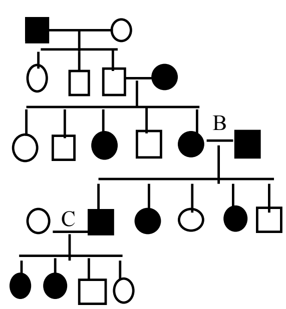
18. The following pedigree shows the presence of individuals bearing extra fingers and toes--exhibiting "polydactyly."



What is the correct mechanism of inheritance for this abnormality, and how can you tell?

a. X-linked dominant
b. x-linked recessive
c. autosomal dominant
d. autosomal recessive
e. y-linked

19. The inheritance of a particular facial hair pattern in a given family is indicated below. Answer the following questions about this family tree.



a. Which is the correct mechanism of inheritance?
autosomal dominant
autosomal recessive
y-linked
x-linked dominant
x-linked recessive

a. Using the symbols "F" and "f" to indicate dominance and recessiveness, show the genotypes of the parents at B.

c. In the marriage at C, what is the probability that the next child born will show the trait?

H. CROSSOVER

20. In the common bluebell, two linked, autosomal genes control flower color and plant height, as follows:

B (blue flowers) > b (white flowers)
T (tall plants) > t (dwarf plants)

If the crossover frequency between these two loci (genes) in 26%, than for the following cross BT//bt x bt//bt

a. what are the kinds and frequencies of gametes that can be produced by each parent?
b. what will be the expected F_1 phenotypes and their frequencies ?

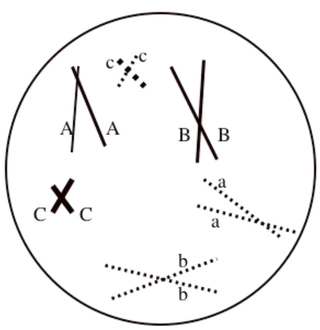
21. In the fruit fly, Drosophila melanogaster, crossing over is absent in the males. Suppose you are interested in the relationship between two linked genes on chromosome 2. The genes are for black body (b) and for curved wings (c), each of which is recessive to the normal (B) body color and normal (C) wing shape. In your laboratory, females that are heterozygous at the body color and wing shape loci are mated with a black-bodied male with curved wings. The offspring of these matings were counted, with the following results:

367 normal body, curved wing
131 normal body, normal wing
139 black body, curved wing
363 black body, normal wing

a. What is the cross-over frequency between these two loci?
b. How many map units separate these two loci?
c. Show the pattern of linkage (coupling or repulsion) in the female flies of this mating?

I. MEIOSIS

22. Assume that the cell below is from an insect testis and is about to undergo spermatogenesis (gamete production by meiosis). The letters represent dominant or recessive alleles at particular gene positions on each chromosome.



a. What is the haploid chromosome number of the insect?
b. How many types of gametes could be formed from this cell assuing no cross-over occurs?
c. How many pairs of homologous chromosomes would you find in a skin cell from this organism?
d. What is the probability that a gamete produced from this cell would carry recessive alleles for all traits shown?
e. Which of Mendel's Laws tells us that a gamete containing a chromosome with an "A" allele will not necessarily also contain a " B" allele?